Appendix B
Glossary

B-1. Abbreviations

A-E . . . . . Architect-Engineer
BIH . . . . . Bureau International de l'Heure
BM . . . . . Benchmark
CCD . . . . . Charge Couple Device
CDMS . . . . . Continuous Deformation Monitoring System
CONUS . . . . . CONtinental United States
CORPSCON . . . . . CORPS CONvert
CSM . . . . . Computer Simulation Method
CTP . . . . . Conventional Terrestrial Pole
CW . . . . . Civil Works
DGPS . . . . . Differential Global Positioning System
DME . . . . . Distance Measuring Equipment
DoD . . . . . Department of Defense
EDM . . . . . Electronic Distance Measurement
EFARS . . . . . Engineer Federal Acquisition Regulation Supplement
E&D . . . . . Engineering and Design
FEM . . . . . Finite Element Method
FGCC . . . . . Federal Geodetic Control Committee
FGCS . . . . . Federal Geodetic Control Subcommittee
FGDC . . . . . Federal Geographic Data Committee
FOA . . . . . Field Operating Activity
GIS . . . . . Geographic Information System
GPS . . . . . Global Postioning System
GRS 80 . . . . . Geodetic Reference System of 1980
HARN . . . . . High Accuracy Regional Networks
HI . . . . . Height of Instrument
IDT . . . . . Indefinite Delivery Type
IGLD 55 . . . . . International Great Lakes Datum of 1955
IGLD 85 . . . . . International Great Lakes Datum of 1985
MHW . . . . . mean high water
MLLW . . . . . mean lower low water
MLW . . . . . mean low water
MSL . . . . . mean sea level
MSL 1912 . . . . . Mean Sea Level Datum of 1912
NAD 27 . . . . . North American Datum of 1927
NAD 83 . . . . . North American Datum of 1983
NADCON . . . . . North American Datum Conversion
NATO . . . . . North Atlantic Treaty Organization
NAVD 88 . . . . . North American Vertical Datum of 1988
NAVSTAR . . . . . NAVigation Satellite Timing and Ranging
NGRS . . . . . National Geodetic Reference System
NGS . . . . . National Geodetic Survey
NGVD 29 . . . . . National Geodetic Vertical Datum 1929
NOAA . . . . . National Oceanic and Atmospheric Administration
NOS . . . . . National Ocean Service
OCONUS . . . . . Outside the Continental United States
OMB . . . . . Office of Management and Budget
PC . . . . . personal computer
RLR . . . . . Reference Line Ratio
RMS . . . . . root mean square
SI . . . . . International System of Units
SPCS . . . . . State Plane Coordinate System
TBM . . . . . temporary benchmark
TEC . . . . . U.S. Army Topographic Engineering Center
TM . . . . . Transverse Mercator
2DRMS . . . . . Two standard deviation root mean square
USACE . . . . . U.S. Army Corps of Engineers
USC&GS . . . . . U.S. Coast & Geodetic Survey
UTM . . . . . Universal Transverse Mercator
VERTCON . . . . . VERTical CONversion
WGS 84 . . . . . World Geodetic System of 1984

B-2. Terms

Abberation of Light (Astronomic)
The apparent displacement in position of a stellar body due to the velocity of light combined with the motion of the earth itself.

Absolute Accuracy
Accuracy that is determined by a specific reference to a value.

Absolute GPS
Operation with a single receiver for a desired position. This receiver may be positioned to be stationary over a point. This mode of positioning is the most common military and civil application.

Accidental Error
Error that is accidentally incurred in a measurement. Unlike systematic errors, accidental errors are not governed by fixed laws. The theory of probability is based

on the occurrence of these errors, which are just as likely to be positive as negative.

Accuracy
A measurement's degree of conformity or perfection. Accuracy relates to the quality of a result and is distinquished from precision which relates to the quality of the operation by which the result is obtained.

Adjustment
Adjustment is the removal of discrepancy errors. This adjustment forms a coordinated and correlated system of stations.

Agonic Line
A line, on the earth's surface, with zero magnetic declination. Equivalently, it is the locus of all points, on the earth's surface, at which magnetic north and astronomic north coincide. It is a particular case of an isogonic line.

Altimeter
An instrument that measures approximate elevations or approximate differences of elevation.

Altitude
The vertical angle between the plane of the observer's true horizon and a line to the object.

Angle of Depression
A negative altitude.

Angle of Elevation
A positive altitude.

Angular Misclosure
Difference in the actual and theoretical sum of a series of angles.

Apparent Time
Time that is directly determined from measurements, i.e., based on the true place of the sun. Apparent time is usually adjusted to remove effects of refraction and aberration from the measurements. Two kinds of apparent time are in common use: apparent sidereal time and apparent solar time.

Archiving
Storing of documents.

Astronomical Latitude
Angle between the plumb line and the plane of celestial equator. Also defined as the angle between the plane of the horizon and the axis of rotation of the earth. Astronomical latitude applies only to positions on the earth and is reckoned from the astronomic equator (0°), north and south through 90°. Astronomical latitude is the latitude which results directly from observations of celestial bodies, uncorrected for deflection of the vertical.

Astronomical Longitude
Arbitrarily chosen angle between the plane of the celestial meridian and the plane of an initial meridian. Astronomical longitude is the longitude which results directly from observations on celestial bodies, uncorrected for deflection of the vertical.

Astronomical Triangle
A "reference triangle" formed by arcs of great circles connecting the celestial pole, the zenith, and a celestial body. The angles of the astronomical triangles are: at the pole, the hour angle; at the celestial body, the parallactic angle; at the zenith, the azimuth angle. The sides are: pole to zenith, the co-latitude; zenith to celestial body, the zenith distance; and celestial body to pole, the polar distance.

Atmospheric Refraction
Refraction of light from a source outside the atmosphere. Also called astronomic refraction. Light from a star or planet passes through the entire depth of the atmosphere before reaching the surface of the earth. Refraction causes the ray to follow a curved path concave toward the surface.

Azimuth
The horizontal direction of a line clockwise from a reference plane, usually the meridian. Often called forward azimuth to differentiate from back azimuth.

Azimuth Angle
The angle less than 180° between the plane of the celestial meridian and the vertical plane with the observed object, reckoned from the direction of the elevated pole. In astronomic work, the azimuth angle is the spherical angle at the zenith in the astronomical triangle which is composed of the pole, the zenith, and the star. In geodetic work, it is the horizontal angle between the celestial pole and the observed terrestrial object.

Azimuth Closure
Difference of the two values derived by different surveys or along different routes. Usually, one value is derived by computations using the measurements made during the survey (traverse, triangulation, or trilateration); the other is an adjusted or fixed value determined by an earlier or

more precise survey or by independent, astronomical observations.

Backsight
1. (traversing) A sight on a previously established traverse or triangulation station and not the closing sight on the traverse. 2. (leveling) A reading on a rod held on a point whose elevation has been previously determined and not the closing sight of a level line.

Barometric Leveling
Determining differences of elevation from differences of atmospheric pressure observed with a barometer. By the application of certain corrections and the use of what is sometimes termed the barometric formula, a difference of atmospheric pressure at two places is transformed into a difference of elevations of those places. If the elevation of one station above a datum (as sea level) is known, the approximate elevations of other stations can be known by barometric leveling. By using barometers of special design, and including several stations of known elevation in a series of occupied stations, the accuracy of the elevations determined for the new stations is increased. Corrections are applied for temperature, latitude, index of barometer, closure of circuit, diurnal variation in atmospheric pressure, etc. Barometric leveling determined differences in height are determined by measuring the differences in atmospheric pressure at various elevations. Air pressure is measured by mercurial or aneroid barometers, or a boiling point thermometer. Although the degree of precision obtainable through this method is not as great as either of the other methods mentioned, it is a method by which to rapidly obtain relative heights at points which are at fair distances apart from each other. It is a method that has been widely used in reconnaissance and exploratory surveys where more exacting measurements will be made later or are not required.

Baseline
1. Resultant three-dimensional vector V between any two stations. Generally given in earth-centered Cartesian coordinates where $V = (\Delta x, \Delta y, \Delta z)$. 2. The primary reference line in a construction coordinate system.

Base Net
Expansion of geometric figures from a baseline to a line of the main scheme of a triangulation net.

Base Points
The beginning points for a traverse that will be used in triangulation or trilateration.

Basic Control
The horizontal and vertical control used for Third-Order or higher order accuracy. It is determined in the field and permanently marked or monumented for further surveys.

Bearing
The direction of a line within a quadrant, with respect to the meridian. Bearings are measured clockwise or counterclockwise from north or south, depending on the quadrant.

Bearing Determination
The correct description of a bearing. It is not adequate to describe a line or bearing as simply northeast or southwest. All bearings meant for USACE applications need to be described as to any degrees, minutes, and seconds in the direction in which the line is progressing. The accuracy of the calculation is dependent on exact measurements. The bearing states its primary direction, north or south, first and then the angle, east or west.

Benchmark
A relatively permanent material object, natural or artificial, on a marked point of known elevation. Usually designated a BM, such a mark is sometimes qualified as a permanent benchmark or PBM to distinguish it from a temporary or supplementary benchmark designated as TBM. TBMs are marks of less permanent character and are intended to serve for only a comparatively short period of time.

Best Fit
To represent a given set of points by the corresponding points of a smooth function, curve, or surface.

Bipod
A two-legged structure used for supporting an instrument or survey signal at a height convenient for the observer.

Bluebook
Another term for the "FGCS Input Formats and Specifications of the National Geodetic Data Base." This is one of many guidelines to follow for geodetic control surveys.

Blunder
A mistake or error caused by mental confusion, carelessness, stupidity, ignorance, or some other factor. Examples of blunders are: reading a horizontal circle wrong by a whole degree; neglecting to record a whole tape length in a traverse; and reversing the numerals in recording a measurement. It would also apply to the number recorded

as the result of observing on the wrong target or from the wrong control point.

Bureau International de l'Heure (BIH)
Coordinates the measurements of time by national observatories and provides an internationally acceptable, common time. It is also responsible for maintaining the international atomic second, i.e., providing to users a unit of time, the second, against which other standards can be calibrated. As part of its function, it calculates the position of the earth's axis of rotation with respect to points on the earth and changes in the earth's rate of rotation. The Bureau was founded in 1919 and its offices since then have been at the Paris Observatory. By an action of the International Astronomical Union, the BIH ceased to exist on 1 January 1988 and a new organization, the International Earth Rotation Service (IERS) was formed to deal with determination of the earth's rotation. The timekeeping portion of the BIH was transferred to the Bureau International des Poids et Mesures (BIPM).

Cadastral Survey
Relates to land boundaries and subdivisions, and creates units suitable for transfer or to define the limitations of title. The term cadastral survey is now used to designate the surveys of the public lands of the U.S., including retracement surveys for identification and resurveys for the restoration of property lines; the term can also be applied properly to corresponding surveys outside the public lands, although such surveys are usually termed land surveys through preference.

Calibration
Determining the systematic errors in an instrument by comparing measurements with an instrument of nearly correct measurements. The correct value is established either by definition or by measurement with a device which has itself been calibrated against a device considered correct. Frequently used instruments are usually calibrated using a measuring device (a working standard) which has itself been calibrated. Working standards are calibrated by comparing them with another calibrated set called laboratory standards, and these in turn are calibrated by comparison with the primary standard. Also called standardization. However, that term is now used to mean the imposition of a standard on otherwise diverse processes and products.

Cartesian Coordinates
A system with its origin at the center of the earth and the x- and y-axes in the plane of the equator. Typically, the x-axis passes through the meridian of Greenwich, and the z-axis coincides with the earth's axis of rotation. The three axes are mutually orthogonal and form a right-handed system.

Cartesian System
A coordinate system consisting of N straight lines (called the axes) intersecting at a common point (called the origin). The nth coordinate ($1 \leq n \leq N$) of a point is the distance between that point and the hyperplane determined by all axes but the nth, and measured parallel to the nth axis. Alternatively, a set of N families of N-1 dimensional hyperplanes such that members of the same family have no line in common, while members of different families intersect in one and only one line. The coordinates of a point are then the set of values of the parameters determining the N hyperplanes passing through that point. The units in which distances are measured need not be the same along all the axes, and the axes need not intersect at right angles. A Cartesian coordinate system (CCS) for which the units of distance are different in different directions is sometimes erroneously called an affine CCS. If all the axes intersect at right angles, the system is called a rectangular CCS or simply a CCS. Otherwise, it is called an oblique CCS. Distances are usually measured from the hyperplane to the point and are assigned a positive or a negative value according to some specified convention.

Celestial Equator
A great circle on the celestial sphere with equidistant points from the celestial poles. The plane of the earth's equator, if extended, would coincide with that of the celestial equator.

Celestial Pole
A reference point at the point of intersection of an indefinite extension of the earth's axis of rotation and the apparent celestial sphere.

Celestial Sphere
An imaginary sphere of infinite radius with the earth as a center. It rotates from east to west on a prolongation of the earth's axis.

Central Meridian
1. The line of constant longitude at the center of a graticule. The central meridian is used as a base for constructing the other lines of the graticule. 2. The meridian used as y-axis in computing tables for a State Plane Coordinate system. The central meridian of the coordinate system usually passes close to the geometric center of the region or zone for which the tables are computed but, to avoid using negative values, is given a large positive value which must be added to all x-coordinates. 3. That

line, on a graticule, which represents a meridian and which is an axis of symmetry for the geometric properties of the graticule.

Chain
Equal to 66 feet or 100 links. The unit of length prescribed by law for the survey of the U.S. public lands. One acre equals 10 square chains. The chain derives its name from the Gunter's chain, which was widely used in early surveys and had the form of a series of links connected together by rings.

Chained Traverse
Observations and measurements performed with tape.

Chaining
Measuring distances on the ground with a graduated tape or with a chain. The term taping is now preferred if a tape is used. Although the chain has been superseded by the graduated tape for making land and other surveys, the term "chaining" has continued in use in some surveying organizations and in places where reference is to surveys of the public lands of the U.S. For the corresponding operation in other surveys, the term taping is preferred. In chaining, the persons who mark the tape's ends are called chainmen.

Chart Datum
For referring soundings of a datum to a chart. It is usually taken to correspond to a low-water elevation, and its depression below mean sea level is represented by the symbol Z_o. Since 1989, chart datum has been implemented to mean lower low water for all marine waters of the U.S., its territories, Commonwealth of Puerto Rico, and Trust Territory of the Pacific Islands.

Chi-square Testing
Test whether the classification of data can be ascribed to chance or to some underlying law.

Chronometer
A portable timekeeper with compensated balance, capable of showing time with extreme precision and accuracy.

Circle Position
A prescribed setting (reading) of the horizontal circle of a direction theodolite, to be used for the observation on the initial station of a series of stations that are to be observed.

Circuit Closure
Difference in some measured function of location from the measurements or calculations carried out for points along a line that begins and ends at the same point.

Circumpolar Star
A star in any given latitude which never goes below the horizon; hence its polar distance must be less than the given latitude. In astronomy only those stars with a polar distance of less than 10◦ are considered in practical problems.

Clarke 1866 Ellipsoid
A rotational ellipsoid with: semi-major axis = 20,926,062 feet (6,378,206.4 m), semi-minor axis = 20,855,121 feet (6,356,583.8 m), flattening (derived) = 1/294.978. This ellipsoid has been in use since 1880, in the U.S., for calculating triangulation. The metric values were calculated using Clarke's legal meter of 1866, and were used in the past in tables based on this ellipsoid. Values based on the value 0.304 800 47 for the ratio of the foot to the meter:

semi-major axis	6,378,274	m
semi-minor axis	6,356,650	m.

Closed Traverse
Starts and ends at the same point or at stations whose positions have been determined by other surveys.

Coefficient of Refraction
The ratio at the point of observation to the angle, at the center of the earth between the point of observation and the point observed.

Collimation
A physical alignment of a survey target or antenna over a mark.

Collimation Error
The angle between the actual line of sight through an optical instrument and the position the line would have in a perfect instrument.

Compass Rule
The correction to be applied to the departure (or latitude) of any course in a traverse has the same ratio to the total misclosure in departure (or latitude) as the length of the course has to the total length of the traverse. Also called

Bowditch's rule. The compass rule is used when it is assumed that the misclosure results as much from errors in measured angles as from errors in measured distances. Care must be used in applying the rule because there is no general agreement on the sign to be used for the misclosure; the corrections must be applied with signs determined by the particular conventions in use.

Compensator
Keeps the line of sight horizontal regardless of the tilt (within limits) of the rest of the instrument. It consists of at least one optical element (prism, mirror, or train of prisms or mirrors) suspended in such a way as to keep its orientation with respect to the direction of gravity fixed. It may be suspended by fine wires of invar or by flexible tapes, or it may be attached as the bob of a pendulum. Then gravity keeps the component from rotating with the rest of the instrument when the instrument is tilted slightly. The arrangement of rotating and nonrotating components is such that a horizontal ray entering the objective lens of a tilted telescope is deflected by the compensator just enough that it passes through the center of the reticle and thence through the ocular to the observer. The compensator of most self-leveling instruments can compensate for about 10' of tilt in the instrument. It replaces the sensitive spirit level formerly attached to the telescope and thereby does away with the need to compensate manually for tilt. A leveling instrument equipped with a compensator is frequently referred to as an automatic level. However, the terms compensator leveling instrument or self-leveling instrument are preferred.

Confidence Level
Accuracy based on a known distribution function; e.g., the normal distribution function or bivariate normal distribution function. Errors are stated as some percentage of the total probability of 100 percent; e.g., a 90 percent confidence level.

Conformal
Map projection that holds true shapes at any points but exaggerates the area.

Contour
An imaginary line on the ground with all points thereof at the same elevation above or below a specified surface of reference. The definition is illustrated by the shore line of an imaginary body of water whose surface is at the elevation represented by the contour. A contour forming a closed loop round lower ground is called a depression contour. Contour should not be confused with contour line; the latter is the term for a line drawn on a map. However, the distinction is ignored by some writers.

Control
1. The coordinated and correlated dimensional data used in geodesy and cartography to determine the positions and elevations of points on the earth's surface or on a cartographic representation of that surface. 2. A collective term for a system of marks or objects on the earth or on a map or a photograph whose positions or elevation, or both, have been or will be determined.

Control Densification
The addition of control throughout an established control region.

Control Monuments
Existing local control or benchmarks that may consist of any Federal, state, local or private agency points.

Control Point
A point with assigned coordinates used in other dependent surveys. The term is sometimes used as a synonym for control station. However, a control point need not be realized by a marker on the ground.

Control Survey
A survey which provides coordinates (horizontal or vertical) of points to which supplementary surveys are adjusted.

Control Traverse
A survey traverse made to establish control.

Conventional Terrestrial Pole (CTP)
The origin of the WGS 84 Cartesian system is the earth's center of mass. The Z-axis is parallel to the direction of the CTP for polar motion, as defined by the Bureau of International de l'Heure (BIH), and equal to the rotation axis of the WGS 84 ellipsoid. The X-axis is the intersection of the WGS 84 reference meridian plane and the CTP's equator, the reference meridian being parallel to the zero meridian defined by the BIH and equal to the X-axis of the WGS 84 ellipsoid. The Y-axis completes a right-handed, earth-centered, earth-fixed orthogonal coordinate system, measured in the plane of the CTP equator 90 degrees east of the X-axis and equal to the Y-axis of the WGS 84 ellipsoid.

Coordinate Transformation
A mathematical or graphic process of obtaining a modified set of coordinates. Transformation is completed

through some combination of rotation of coordinate axes at their point of origin, modification of scale along coordinate axes, or change of the size of geometry of the reference space.

CORPSCON
(Corps Convert) Software package (based on NADCON) capable of performing transformations between NAD 83 and NAD 27 geographical coordinates, CORPSCON also converts between State Plane Coordinates System (SPCS), geographical coordinates, and Universal Transverse Mercator (UTM) coordinates; thus eliminating several steps in the total process of converting between grid coordinates on NAD 27 and NAD 83. Inputs can be either in geographic, UTM, or SPCS coordinates. This program can also be used to convert between grid and geographic coordinates on the same datum.

Crandall Method
The misclosure in azimuth or angle is first distributed in equal portions to all the measured angles. The adjusted angles are then held fixed and all remaining corrections distributed among the measurements of distance through the method of weighted least-squares.

Cross sections
A survey line run normal to the alignment of a project, channel, or structure.

Culmination
The instant when any point on the celestial sphere is on the meridian of an observer. When it is on that half of the meridian containing the zenith, it is called the upper transit; when it is on the other half, it is called the lower transit.

Curvature
1. The rate at which a curve deviates from a straight line. 2. The vector dt/ds, where t is the vector tangent to a curve and s is the distance along that curve. 3. The rate at which a curved surface deviates from a flat surface in a particular direction.

Datum
Any numerical or geometrical quantity or set of such quantities which serve as a reference or base for other quantities.

Declination
The angle, at the center of the celestial sphere, between the plane of the celestial equator and a line from the center to the point of interest (on a celestial body). Declination, conventionally denoted by δ, is measured by the arc of hour circle between the celestial body and the equator; it is positive when the body is north of the equator and negative when south of it. It corresponds to latitude on the earth and with right ascension forms a pair of coordinates which defines the position of a body on the celestial sphere.

Deflection of the Vertical
The angular difference, at any place, between the upward direction of a plumb line (the vertical) and the perpendicular (the normal) to the reference spheroid. This difference seldom exceeds 30 seconds. Often expressed in two components, meridian and the prime vertical.

Deflection Traverse
Direction of each course measured as an angle from the direction of the preceding course. A deflection traverse is usually an open traverse.

Deformation Monitoring
Observing the conditions of dams. It is necessary to keep accurate records of normal occurrences to differentiate between possible hazards and normal changes.

Departure
The orthogonal projection of a line, on the ground, onto an east-west axis of reference. The departure of a line is the difference of the meridional distances or longitudes of the ends of the line. It is east, or positive, and is sometimes called the easting, for a line whose azimuth or bearing is in the northeast or southeast quadrant. It is west, or negative, and is sometimes called the westing, for a line whose azimuth or bearing is in the southwest or northwest quadrant. It is abbreviated as dep. in notes.

Differential GPS
Process of measuring the differences in coordinates between two receiver points, each of which is simultaneously observing/measuring satellite code ranges and/or carrier phases from the NAVSTAR GPS constellation. The process actually involves the measurement of the difference in ranges between the satellites and two or more ground observing points. The basic principle is that the absolute positioning errors at the two receiver points will be approximately the same for a given instant in time. The resultant accuracy is extremely high. This type of positioning can be performed in either a static or kinematic mode.

Differential Leveling
The process of measuring the difference of elevation between any two points by spirit leveling.

Direction
1. The angle between a line or plane and an arbitrarily chosen reference line or plane. At a triangulation station, observed horizontal angles are referred to a common reference line and termed horizontal direction. They are usually collected into a single list of directions, with the direction of 0° placed first and the other directions arranged in order of increase clockwise. 2. A line, real or imaginary, pointing away from some specified point or locality toward another point. Direction has two meanings: that of a numerical value and that of a pointing line. Two lines must be specified for the first definition to be valid; only one line need be specified for the second meaning. 3. An indication of the location of one point with respect to another without involving the distance between the two points. It is usually thought of as a short segment (of a straight line between the two points) having one end at one of the points and having an arrow-like symbol at the other end. Note that a direction is not an angle.

Direct Leveling
The determination of differences of elevation through a continuous series of short horizontal lines. Vertical distances from these lines to adjacent ground marks are determined by direct observations on graduated rods with a leveling instrument equipped with a spirit level.

Distance Angle
An angle in a triangle opposite a side used as a base in the solution of the triangle, or a side whose length is to be computed.

Dumpy Level
The telescope permanently attached to the leveling base, either rigidly to or by a hinge that can be manipulated by a micrometer screw.

Dynamic Height
That vertical distance between the point P_n on the earth's surface and the point P_o on the geoid which is given by the function $\int (g/\tau_{45})\, dH$ (the integral being taken from P_o to P_n), in which g is the value of gravity acceleration along the path of integration, τ_{45} is the value of gravity at 45° latitude, as calculated from a standard gravity formula, and dH is the increment of vertical distance along the path of integration. Also called dynamic number.

Earth-Centered Ellipsoid
Center at the earth's center of mass and minor axis coincident with the earth's axis of rotation.

Earth Curvature
The curvature of an ellipsoid representing the earth. In surveying over short distances, if the earth's curvature needs to be taken into account at all, representing the earth by a sphere is adequate.

Easting
The distance eastward (positive) or westward (negative) of a point from a particular meridian taken as reference. (It is common practice to use positive westings instead of negative eastings.)

Eccentricity
The ratio of the distance from the center of an ellipse to its focus on the semimajor axis.

Ecliptic
The intersection of the plane of the earth's orbit with the celestial sphere.

Electronic Distance Measurement (EDM)
Pulsing of phase comparison to determine a distance.

Elevation
The height of an object above some reference datum.

Ellipsoid
Formed by revolving an ellipse about its minor axis. An ellipsoid is defined by the length of its semimajor axis *a* and its flattening *f*, where: $f = (a-b)/a$ and b = length of the semiminor axis. The most commonly used ellipsoids in North America are: Clarke 1866, Geodetic Reference System of 1980 (GRS 80), World Geodetic System of 1972 (WGS 72), and World Geodetic System of 1984 (WGS 84). Prior to January 1987, GPS operated with reference to WGS 72. Since January 1987, it has been referenced to WGS 84. For most purposes, GRS 80 and WGS 84 can be considered identical.

Ellipsoid Height
The elevation *h* of a point above or below the ellipsoid.

Elongation
That point in the apparent movement of a circumpolar star when it has reached the extreme position east or west of the meridian.

Emulsion
A suspension of either light-sensitive silver salts, Diazos, or photopolymers, in a colloidal medium which is used for coating films, plates, and papers.

Ephemeris Time
The uniform measure of time defined by the laws of dynamics and determined in principal from the oribital motions of the planets, specifically in the orbital motion of the earth as represented by Newcomb's "Tables of the Sun."

Equation of Time
The algebraic difference in hour angle between apparent solar time and mean solar time, usually labeled + or - as it is to be applied to mean solar time to obtain apparent solar time.

Equinox
One of the two points of intersection of the ecliptic and the celestial equator, occupied by the sun when its declination is 0°.

Error
1. The difference between the measured value of a quantity and the theoretical or defined value of that quantity: ε(error) $\equiv$ y (measured) - y (theoretical). 2. The difference between an observed or calculated value of a quantity and the ideal or true value of that quantity. Logically, definitions (1) and (2) are distinctly different. In practice, they are equivalent except for the second definition's allowing calculated values to be used instead of measured values.

Error Ellipse
Containing a specified percentage of randomly distributed points or having a specified value for the quadratic form $[(\xi / \sigma_x)^2 - 2\rho (\xi / \sigma_x) (\eta / \sigma_y) + (\eta / \sigma_y)^2] / (1 - \rho^2)$, in which σ_x and σ_y are the standard deviations of x and y, respectively, and ρ is the correlation coefficient. Also called an ellipse of error and contour ellipse. Unless specifically stated otherwise, the distribution is assumed to be bivariate Gaussian.

Error of Closure
Difference in related measurements of the true or fixed value of the same quantity.

Exterior Angle
One of the angles lying outside a pair of parallel lines intersected by a third line.

External Accuracy
A measure of the closeness of a set of values, measured or calculated, to the true value.

Finite Element Method
Obtaining an approximate solution to a problem for which the governing equations and boundary conditions are known. The method divides the region of interest into numerous, interconnected subregions (finite elements) over which simple, approximating functions are used to represent the unknown quantities. The basic idea originated in the early 1900's as a method of solving for strains in bridges and buildings. It was further developed for analyzing the structure of aircraft in the early 1950's. The method, supported by rigorous mathematical theory, has now been applied to problems in heat flow, hydraulics, geodynamics, and other disciplines.

Fixed Elevation
Adopted, either as a result of tide observations or previous adjustment of spirit leveling, and which is held at its accepted value in any subsequent adjustment.

Foresight
1. An observation of the distance and direction to the next instrument station. 2. (transit traverse) A point set ahead to be used for reference when resetting the transit or line or when verifying the alinement. 3. (leveling) The reading on a rod that is held at a point whose elevation is to be determined.

Free Adjustment
1. An adjustment in which the number of unknowns is greater than the number of independent equations relating the unknowns to observations. Such an adjustment has, in general, no unique solution. More or less arbitrary conditions must therefore be imposed on the unknowns to obtain a unique solution. 2. An adjustment in which the number of unknowns is greater than the number of independent equations relating the unknowns to observations, but there are just enough conditions imposed on the unknowns to produce a unique solution. 3. The adjustment of a network containing no fixed quantities. 4. An adjustment in which the rank of the normal matrix, exclusive of that part associated with Lagrangian multipliers, is equal to the order of the normal matrix. 5. An adjustment of geodetic coordinates in which, if the number of points with unknown coordinates is N, there are 3N unknowns in 3-space (or 2N unknowns in 2-space) and there are 6 (or 3) condition equations. Also called adjustment using minimal constraints or inner adjustment.

Frequency
The number of complete cycles per second existing in any form of wave motion.

Geocentric Coordinates
1. One of a set of three coordinates, of a point, in a geocentric coordinate system. The coordinates are commonly represented by (λ, ϕ', r) where λ, the longitude, is the angle from a reference plane through the polar axis to the plane containing the polar axis and the point; ϕ', the geocentric latitude, is the angle from the equatorial plane to the radius vector to the point; and r, the geocentric distance or geocentric radius, is the distance of the point from the center. The letter ψ is frequently used instead of ϕ'. Note that the origin (intersection of polar axis and equatorial plane, or center of reference ellipsoid if one is used) need not be at the earth's center of mass or geometric center. The complete set of three geocentric coordinates is also called a geocentric position. 2. One of a set of coordinates designating the location of a point by means of (a) the angle from the plane of the celestial equator to a line from the center of the earth to the point and (b) the angle from the plane of a selected, initial geodetic meridian to that line. The first angle is called the geocentric latitude. The term geocentric longitude is not used for the second angle because that angle is the same as the geodetic longitude. This definition properly applies only to the exceptional case where the plane of the equator passes through the center of the earth and the polar axis of the reference ellipsoid coincides with the earth's polar axis. 3. The longitude and latitude of a point (on the earth's surface) relative to the center of the earth. The earth's center of mass is usually meant.

Geodesic Line
Shortest distance between any two points on any mathematically defined surface. A geodesic line is a line of double curvature, and usually lies between the two normal section lines which the two points determine. If the two terminal points are in nearly the same latitude, the geodesic line may cross one of the normal section lines. It should be noted that, except along the equator and along the meridians, the geodesic line is not a plane curve and cannot be sighted over directly. However, for conventional triangulation the lengths and directions of geodesic lines differ inappreciably from corresponding pairs of normal section lines.

Geodesy
Determination of the size and figure of the earth (geoid) by such direct measurements as triangulation, leveling, and gravimetric observations.

Geodetic Control
Established and adjusted horizontal and/or vertical control in which the shape and size of the earth (geoid) have been considered in position computations.

Geodetic Coordinates (ϕ, λ, H)
Angular latitudinal and longitudal coordinates, usually referenced to some defined ellipsoid of revolution.

Geodetic Height
The perpendicular distance from a specified ellipsoid (reference ellipsoid) to the point of interest. Note that geodesists distinguish sharply between geodetic height, which is measured along the perpendicular to the reference ellipsoid, and elevation, which is measured along the vertical to the reference surface. Conventionally, h is used for geodetic heights, H for elevations.

Geodetic Latitude
The angle which the normal at a point on the reference spheroid makes with the plane of the geodetic equator. Geodetic latitudes are reckoned from the equator, but in the horizontal-control survey of the U.S. they are computed from the latitude of station Meades Ranch as prescribed in the North American Datum of 1927.

Geodetic Leveling
The observation of the differences in elevation by means of a continuous series of short horizontal lines of sight. Vertical distances from these lines to adjacent ground marks are determined by direct observations on graduated rods with a leveling instrument equipped with a spirit level or pendulum apparatus (compensator) that senses the vertical/ horizontal directions. This is the most accurate method of determining elevations.

Geodetic Longitude
The arbitrarily chosen angle between the plane of the geodetic meridian and the plane of an initial meridian. A geodetic longitude can be measured by the angle at the pole of rotation of the reference spheroid between the local and initial meridians, or by the arc of the geodetic equator intercepted by those meridians. In the U.S., geodetic longitudes are numbered from the meridian of Greenwich, but are computed from the meridian of station Meades Ranch as prescribed in the North American Datum of 1927. A geodetic longitude differs from the corresponding astronomical longitude by the amount of the prime vertical component of the local deflection of the vertical divided by the cosine of the latitude.

Geodetic North
1. That direction, along a tangent to a meridian on an oblate, rotational ellipsoid representing the earth, which is approximately that of astronomic north. Also called true north, although that term is usually applied only to astronomic north. 2. The direction of a vector parallel to the minor axis of an oblate, rotational ellipsoid and directed approximately toward astronomic north.

Geodetic Reference System of 1980 (GRS 80)
The following set of numbers adopted in 1979 by the International Union of Geodesy and Geophysics:

a	6 378 137 meters
GM	98 600.6 x 10^9 m^3/s^2
J_2 (- C_{20})	-0.001 082 63
ω	729 211.5 x 10^{-11} radians/s.

a is the length of the semimajor axis of an equipotential, rotational ellipsoid, GM is the product of the gravitational constant G by the mass M of the earth, and C_{20} is the coefficient of the second-degree Legendre function in the representation V of the earth's gravitational potential $V = (GM/a) \Sigma_n [(a/r)\ n+1\ \Sigma_n \{(C_{nm} \cos m\lambda + S_{nm} \sin m\lambda)\ P_{nm} (\sin \phi)\}]$, in which r is geocentric distance, ϕ is geocentric latitude, and λ is geodetic longitude. ω is the angular rate of rotation of the ellipsoidal body.

Geographic Coordinates
1. A general term for either a geodetic or an astronomic coordinate. Also called a terrestrial coordinate. The pair of geographic coordinates is also called a geographic location or a geographic position. 2. One of a pair of coordinates which specify the angle between a specified line and a meridional plane and the angle between that line and an equatorial plane.

Geoid
An equipotential surface approximating the earth's surface and corresponding with mean sea level in the oceans and its extension through the continents. In other words, the geoid would coincide with the surface to which the oceans would conform over the entire earth if the oceans were set free to adjust to the combined effect of the earth's mass attraction and the centrifugal force of the earth's rotation.

GPS (Global Positioning System)
The NAVSTAR satellites in six different orbits, five monitor stations and the user community.

Gravimeter
Registers variations in the weight of a constant mass when the mass is moved from place to place on the earth. It is subjected to the influence of gravity at those places.

Gravity
Viewed from a frame of reference fixed in the earth, acceleration imparted by the earth to a mass which is rotating the earth. Since the earth is rotating, the acceleration observed as gravity is the resultant of the acceleration of gravitation and the centrifugal acceleration arising from this rotation and the use of an earthbound rotating frame of reference. It is directed normal to sea level and to its geopotential surfaces.

Greenwich Meridian
The astronomic meridian through the center of the Airy transit instrument of the Greenwich Observatory, Greenwich, England. By international agreement in 1884, the Greenwich meridian was adopted as the meridian from which all longitudes, worldwide, would be calculated. Observations to maintain the Greenwich meridian as reference are no longer made at the Airy transit or, for that matter, at the Greenwich Observatory. Instead, they are made (1986) at Herstmanceaux Observatory, England, and the observations made there are reduced, by calculation, to the equivalent values at the Airy transit. A meridian close to that of Greenwich but used as a reference for determining time internationally is maintained by the Bureau International de l'Heure. Although the definitions of the Greenwich meridian and of the meridian used as reference for times are valid, neither provides a fixed reference for either longitude or time. The meridian of Greenwich changes its position with respect to meridians at other observatories because of geological changes in the region surrounding the Greenwich Observatory. The meridian provided by the Bureau International de l'Heure is affected by the errors in time signals from the stations monitored by the Bureau.

Grid Azimuth
The angle, in the plane of projection, between a straight line and the line (y-axis), in a plane rectangular coordinate system, representing the central meridian. In the State Plane Coordinate System established by the U.S. Coast and Geodetic Survey, grid azimuths were reckoned from south (0°) clockwise through 360°. To reduce geodetic azimuth to grid azimuth, a quantity $[y_2 - y_1)\ (2x' + x_2')]/(6\ r_o \sin 1")$ should be subtracted from the geodetic azimuth if the line is more than 7 km long and if full

accuracy is wanted. (x_i', y_i are the coordinates of the points whose azimuth is wanted, and the denominator is a constant for the coordinate system of a particular State and is given in the tables of plane rectangular coordinates for that State). While essentially a map-related quantity, a grid azimuth may, by mathematical processes, be transformed into a survey-related or ground-related quantity.

Grid Inverse
The computation of length and azimuth from coordinates on a grid.

Grid Meridian
1. That line, in a grid on a map, parallel to the line representing the central meridian or y-axis. 2. That line, in a rectangular, Cartesian coordinate system applied to a map, parallel to the line representing the y-axis or central meridian.

Gulf Coast Low Water Datum (GCLWD)
Used as chart datum for the coastal waters of the Gulf Coast of the U.S. It is defined as mean lower low water when the tide is of the mixed type and as mean low water when the tides are diurnal. The datum was abandoned by the National Ocean Survey in 1980 and replaced by mean lower low water for the region involved.

Gunter's Chain
A measuring device once used in land surveying. It was composed of 100 metallic links fastened together with rings. The total length of the chain is 66 feet. Also called a four-pole chain. Invented by the English astronomer Edmund Gunter about 1620, it is the basis for the chain and link, units of length used in surveying the public lands of the USA. The original form of the chain has been replaced by metallic tapes or ribbons graduated in links and chains, but the new forms are still called chains.

Gyrotheodolite
A built-in gyroscopic compass to measure angles with respect to that North indicated by the compass. Also called a gyro-azimuth theodolite, gyroscopic meridian-indicating instrument, gyro-meridian indicating instrument and gyroscopic theodolite. The instrument is particularly useful in mines and other places (such as the far north) where direction is difficult to establish by other means.

Hachures
Portraying relief by short, wedge-shaped marks radiating from high elevations and following the direction of slope to the lowland.

Heliotrope
One or more plane mirrors so mounted at the station being sighted upon, that the sun's rays can be reflected to any one observing station.

Histogram
A graphical representation of a frequency function. The frequency of occurrence is indicated by the height of a rectangle whose base is proportional to the interval within which the events occur with the indicated frequency.

Horizontal Control
Determines horizontal positions only, with respect to parallels and meridians or to other lines of reference.

Horizontal Refraction
A natural error in surveying. The result of the horizontal bending of light rays between a target and an observing instrument causes this refraction. Usually caused by the differences in density of the air along the path of the light rays, resulting from temperature variations.

Hour Angle
Angular distance west of a celestial meridian or hour circle; the arc of the celestial equator, or the angle at the celestial pole, between the upper branch of a celestial meridian or hour circle and the hour circle of a celestial body or the vernal equinox, measured westward through 360°.

Hour Circle
Any great circle on the celestial sphere whose plane is perpendicular to the plane of the celestial equator.

Index Error
1. A systematic error caused by misplacement of an index mark or zero mark on an instrument having a scale or vernier, so that the instrument gives a nonzero reading when it should give a reading of zero. This is a constant error. 2. The distance upward (or downward) from the foot of a leveling rod (the lowest horizontal surface) to the nominal origin (theoretical zero) of the scale.

Indirect Leveling
The determination of differences of elevation from vertical angles and horizontal distances, as in *trigonometric leveling*; comparative elevations derived from values of atmospheric pressure determined with a barometer, as in *barometric leveling*; and elevations derived from values of the boiling point of water determined with a hypsometer, as in *thermometric leveling.*

Interior Angle
An angle between adjacent sides of a closed figure and lying on the inside of the figure. The three angles within a triangle are interior angles.

International Foot
Defined by the ratio 30.48/100 m.

International Great Lakes Datum of 1955 (IGLD 55)
Vertical reference datum used in the Great Lakes and their connecting waterways.

International Great Lakes Datum of 1985 (IGLD 85)
The adjustment of IGLD 55 used data collected from 1982-1988. The most significant change is in elevations assigned to water levels. The water levels established for Canadian zoning restrictions and U.S. flood insurance purposes will not change. The implementation and publication of IGLD 85 occurred in January 1992, and should be used for at least 25 years.

International System of Units (SI)
A self-consistent system of units adopted by the general Conference on Weights and Measures in 1960 as a modification of the then-existing metric system, changed in 1983.

Interpolation Method
1. Determination of an intermediate value between given values, from some known or assumed rate or system of change of values between the given ones. Equivalently, determination of the value of a function $y = f(x)$ for some arbitrarily specified value of x, given values (y_1, x_1) and (y_2, x_2) such that the arbitrary value of x lies between the two given values. 2. The process or technique of obtaining an estimate of the value of a quantity at a specified time t, given that data useful for obtaining the estimate are available for times both before and after t. This definition seems to be part of the jargon of control engineering, in which it is called smoothing.

Intersection
Determining the horizontal position of a point by observations from two or more points of known position. Thus measuring directions that intersect at the station being located. A station whose horizontal position is located by intersection is known as an intersection station.

Intervisibility
When two stations can see each other in a survey net.

Invar
An alloy of iron containing about 64% iron, 36% nickel, and small amounts of chromium to increase hardness, manganese to facilitate drawing, and carbon to raise the elastic limit, and having a very low coefficient of thermal expansion (about 1/25 that of steel). It was invented by C. Guillaume of the International Bureau of Weights and Measures (Paris). It is used wherever a metal does not change its dimensions appreciably with temperature as desired. For this reason, it or a similar alloy has replaced steel in surveyor's tapes and wires, and particularly in those tapes and wires used for measuring geodetic baselines. It is also used for the scale of some leveling rods, in first-order leveling instruments, and in pendulums.

Isogonic Chart
A system of isogonic lines, each for a different value of the magnetic declination.

Isogonic Line
A line drawn on a chart or map and connecting all points representing points on the earth having equal magnetic declination at a given time. Also called an isogonal.

Kinematic Survey Methods
Requires two receivers recording observations simultaneously. It is often referred to as dynamic surveying. As in stop-and-go surveying, the reference receiver remains fixed on a known control point while the rover receiver collects data on a constantly moving platform. Unlike stop-and-go surveying, kinematic surveying techniques do not require the rover receiver to remain motionless over the unknown point. The observation data are later postprocessed by computer to calculate relative vector/coordinate differences to the roving receiver.

Laplace Azimuth
A geodetic azimuth derived from an astronomic azimuth by use of the Laplace equation.

Laplace Condition
Arises from the fact that a deflection of the vertical in the plane of the prime vertical will give a difference between astronomic and geodetic longitude and between astronomic and geodetic azimuth. Conversely, the observed differences between astronomic and geodetic values of the longitude and of the azimuth may both be used to determine the deflection in the plane of the prime vertical.

Laplace Equation
Expresses the relationship between astronomic and geodetic azimuths in terms of astronomic and geodetic

longitudes and geodetic latitude. Thus Laplace correction = $(\lambda_A - \lambda_G) \sin \phi_G$.

Laplace Station
A triangulation or traverse station at which a Laplace azimuth is determined. At a Laplace station both astronomic longitude and astronomic azimuth are determined.

Least Count
The finest reading that can be made directly (without estimation) from a vernier or micrometer.

Least Squares Adjustment
The adjustment of the values of either the measured angles or the measured distances in a traverse by determining the corrections so that the sum of the squares of the corrections is a minimum.

Length of Closure
The distance defined by the equation:
$[(\text{closure of latitude})^2 + (\text{closure of departure})^2]^{0.5}$

Level
Any device sensitive to the direction of gravity and used to indicate directions perpendicular to that of gravity at a point.

Level Datum
A level surface to which elevations are referred. The generally adopted level datum for leveling in the U.S. is mean sea level. For local surveys, an arbitrary level datum is often adopted and defined in terms of an assumed elevation for some physical mark (benchmark).

Level Net
Lines of spirit leveling connected together to form a system of loops or circuits extending over an area.

Line of Sight
1. The straight line between two points. This line is in the direction of a great circle, but does not follow the curvature of the earth. 2. The line extending from an instrument along which distant objects are seen, when viewed with a telescope or other sighting device.

Local Coordinate System
The origin is within the region being studied and used principally for points within that region.

Local Datum
Defines a coordinate system which is used only over a region of very limited extent.

Local Hour Angle
Angular distance measured on the celestial equator between the celestial meridian and the hour circle that passes through the object. The local hour angle represents physically the amount of rotation of the celestial sphere, since the object was last on the observer's celestial meridian, and is always measured westward 0° to 360° from the celestial meridian.

Loop
A pattern of measurements in the field, so that the final measurement is made at the same place as the first measurement.

Loop Traverse
A closed traverse that starts and ends at the same station.

Lovar
An alloy having a coefficient of expansion between that of steel and that of invar but costing considerably less than invar.

Magnetic Bearing
The angle with respect to magnetic north or magnetic south and stated as east or west of the magnetic meridian, e.g., N 15°E.

Magnetic Meridian
1. The vertical plane in which a freely suspended, symmetrically magnetized needle, influenced by no transient, artificial, magnetic disturbance, will come to rest. 2. The curve, on the earth's surface at all points of which the vertical plane described in the preceding definition is tangent to the curve. 3. The direction, at any point, of the horizontal component of the earth's magnetic field.

Map
A conventional representation, usually on a plane surface and at an established scale, of the physical features (natural, artificial, or both) of a part or whole of the earth's surface by means of signs and symbols and with the means of orientation indicated.

Map Accuracy
The accuracy with which a map represents. Three types of error commonly occur on maps: errors of representation, which occur because conventional signs must be used to represent natural or man-made features such as forests, buildings, and cities; errors of identification, which occur because a nonexistent feature is shown or is misidentified; and errors of position, which occur when an object is shown in the wrong position. Errors of position

are commonly classified into two types: errors of horizontal location and errors of elevation. A third type, often neglected, is errors of orientation.

Map Scale
The ratio of a specified distance, or the average ratio of specified distances, on a map to the corresponding distance or distances on the ellipsoid used in making the map (i.e., used in the map projection).

Mean Angle
Average of the angles.

Mean Lower Low Water (MLLW)
The average height of all lower low waters recorded over a 19-year period. It is usually associated with a tide exhibiting mixed characteristics.

Mean Sea Level Datum
Adopted as a standard datum for heights or elevations. The Sea Level Datum of 1929, the current standard for geodetic leveling in the U.S., is based on tidal observations over a number of years at various tide stations along the coasts.

Mean Sea Level Datum of 1912 (MSL 1912)
MSL 1912 was the last adjustment before the Sea Level Datum of 1929 was established and only included level lines of the U.S.

Meridian Angle
Angular distance east or west of the local celestial meridian, the arc of the celestial equator, or the angle at the celestial pole, between the upper branch of the local celestial meridian and the hour circle of a celestial body, measured eastward or westward from the local celestial meridian through 180°, and labeled E or W to indicate the direction of measurement.

Metric Unit
Belonging to or derived from the c.g.s. or SI system of units.

Micrometer
1. In general, any instrument for measuring small distances or angles very accurately. 2. In astronomy and geodesy, a device, for attachment to a telescope or microscope, consisting of a mark moved across the field of view by a screw connected to a graduated drum and vernier. If the mark is a hairlike filament, the micrometer is called a filar micrometer.

Misclosure
1. In general, the amount by which a value (of a quantity) obtained by surveying fails to agree with a value (of the same quantity) determined, e.g., by an earlier survey, an arbitrarily assigned starting value, or from theory. Also called closure, closing error, and error of closure. 2. In leveling, the amount by which the two values for the elevation of the same benchmark, derived by different surveys, by the same survey made along two different routes, or by independent measurements, fail to exactly equal each other. The misclosure may occur in a line of leveling beginning and ending on different benchmarks whose elevations are held fixed, or beginning and ending on the same benchmark. 3. (traversing) The amount by which a value for a component of the location (of a traverse station) obtained by computation fails to agree with another value for the component as determined by a set of measurements over the same or a different route. Also called closure, error in closure, traverse error in closure, closure in position, total closure, and misclosure in position. The traverse may run between two stations whose locations are held fixed or it may begin and end at the same station. In either case, there are two values for the location of the final station: one known before the traverse was computed and the other obtained by computation using the measurements made on the traverse. The difference between these is the misclosure. It may be resolved into misclosure in latitude, misclosure in longitude (departure), or both. Although the definition calls for the difference (computed value minus measured value), in practice the difference may be taken either way and corrections applied in an ad hoc manner.

Monument
Indication of the position on the ground of a survey station. In military surveys, the term monument usually refers to a stone or concrete station marker containing a special bronze plate on which the exact station point is marked.

NADCON
The National Geodetic Survey developed the conversion program NADCON (North American Datum Conversion) to provide consistent results when converting to and from North American Datum of 1983. The technique used is based on a bi-harmonic equation classically used to model plate deflections. NADCON works exclusively in geographical coordinates (latitude/longitude).

Nadir
The point on the terrestrial sphere directly beneath the observer and directly opposite to the zenith; the lowest point.

National Geodetic Vertical Datum 1929 (NGVD 29)
Adopted as the standard geodetic datum for heights, based on an adjustment holding 26 primary tide stations in North America fixed. The latest general adjustment is the NGVD 29. Portions of the upper Mississippi River are referenced to the previous (1912) general adjustment. A new readjustment is currently in progress, and will be termed the North American Vertical Datum of 1988 (NAVD 88) when completed. NGVD is not the same as mean sea level.

National Map Accuracy Standards
Set by the U.S., specifying the accuracy required of topographic maps published by the U.S. at various scales. The standards for horizontal accuracy specify that for maps at scales larger than 1:20,000, 90% of all well-defined features (with the exception of those unavoidably displaced by exaggerated symbolization) shall be located within 1/30 inch (0.85 mm) of their geographic locations as referred to the graticule, while for maps published at scales of 1:20,000 or smaller, 1/50 inch (0.50 mm) is the criterion. The standards for vertical accuracy specify that 90% of all contours and elevations determined from contour lines shall be accurate to within one-half of the basic contour interval. Errors (of contours and elevations) greater than this may be decreased by assuming a horizontal displacement within 1/50 inch (0.50 mm).

National Tidal Datum Epoch
A period of 19 years adopted by the National Ocean Survey as the period over which observations of tides are to be taken and reduced to average values for tidal datums. The epoch is designated by giving the year the period began and the year it ended, e.g., National Tidal Datum Epoch of 1941 through 1959.

Network
Interconnected system of points. Although there are different networks of horizontal and vertical control, they are all based on data observed with instruments oriented to the earth's gravity field.

Non-SI units
Units of measurement not associated with International System of Units (SI).

North American Datum of 1927 (NAD 27)
The initial point of this datum is located at Meades Ranch, Kansas. Based on the Clarke spheroid of 1866, the geodetic positions of this system are derived from a readjustment of the triangulation of the entire country, in which Laplace azimuths were introduced.

North American Datum of 1983 (NAD 83)
Covers all of North America and extends into Greenland. NAD 83 was developed by coordinated efforts between the countries covered by the system, and essentially completed by 1988. The datum of the North American Datum 1983 geodetic system is, for practical purposes, equivalent to that of the World Geodetic System 1984. Coordinates of points in the system are not, however, the same because they are determined by including in the adjustment besides data from the TRANSIT (Navy Navigation Satellite System), data from traverses, triangulation, and the GPS.

North American Vertical Datum of 1988 (NAVD 88)
Defined by only one tidal station in Quebec, Canada. NAVD 88 is the new datum and before its advent, all leveling was referred to NGVD 1929.

Northing
A linear distance, in the coordinate system of a map grid, northward from the east-west line through the origin (or false origin).

Observed Angle
May or may not have been corrected for local conditions only, at the point of observations.

Observer's Meridian
A celestial meridian passing through the zenith at the point of observation and the celestial poles.

Occultation
Applied to a geodetic survey technique which employs the principle of occultation where repeated observations are made on an unknown position, accurately timed with similar observations at another unknown station, and mathematically reducing these data to determine the exact geodetic position of the unknown stations.

Open Traverse
Begins from a station of known or adopted position, but does not end upon such a station.

Optical Micrometer
Consists of a prism or lens placed in the path of light entering a telescope and rotatable, by means of a graduated linkage, about a horizontal axis perpendicular to the optical axis of the telescope axis. Also called an optical--mechanical compensator. The device is usually placed in front of the objective of a telescope, but may be placed immediately after it. The parallel-plate optical micrometer is the form usually found in leveling instruments.

Optical Plummet
A small telescope having a 90° bend in its optical axis and attached to an instrument in such a way that the line of sight proceeds horizontally from the eyepiece to a point on the vertical axis of the instrument and from that point vertically downward. In use, the observer, looking into the plummet, brings a point on the instrument vertically above a specified point (usually a geodetic or other mark) below it. An optical plummet is not affected by wind and is therefore superior to the plumb line in this respect. Most modern theodolites have an optical plummet built into the base of the instrument, so that the upright section of the optical axis of the plummet coincides with the vertical axis of the theodolite. The eyepiece is usually located near the base.

Order of Accuracy
Defines the general accuracy of the measurements made in a survey. The order of accuracy of surveys is divided into four classes labeled: first order, second order, third order, and fourth or lower order.

Origin
1. That point, in a coordinate system, which has defined coordinates and not coordinates determined by measurement. This point is usually given the coordinates (0,0) in a coordinate system in the plane and (0,0,0) in a coordinate system in space. In surveying, when a plane rectangular coordinate system is used, the coordinates of the origin are often given large, positive values. These values are called false easting (or false westing) and false northing (or false southing). 2. The point to which the coordinates (0,0,0,....0) are assigned, regardless of the location of that point with respect to the axes of the coordinate system. 3. The point from which coordinates of other points in the coordinate system are reckoned. 4. (of a datum) A point whose coordinates are defined and are part of a datum (usually a geodetic datum). The origin is usually a survey station.

Orthometric Height
The elevation H of a point above or below the geoid. A relationship between ellipsoid heights and orthometric heights is obtained from the following equation: $h = H + N$ where h = ellipsoidal height, H = orthometric height, and N = geoidal height.

Parallax
The apparent displacement of the position of a body, with respect to a reference point or system, caused by a shift in the point of observation.

Personal Equation
The time interval between the sensory perception of a phenomenon and the motor reaction thereto. A personal equation may be either positive or negative, as an observer may anticipate the occurrence of an event, or wait until he actually sees it occur before making a record. This is a systematic error, treated as the constant type.

Personal Error
Caused by an individual's personal habits, his inability to perceive or measure dimensional values exactly, or by his tendency to react mentally and physically in a uniform manner under similar conditions.

Philadelphia Leveling Rod
Having a target but with graduations so styled that the rod may also be used as a self-reading leveling rod. Also called a Philadelphia rod. If a length greater than 7 feet is needed, the target is clamped at 7 feet and raised by extending the rod. When the target is used, the rod is read by vernier to 0.001 foot. When the rod is used as a self-reading leveling rod, the rod is read to 0.005 foot.

Photogrammetry
Deducing the physical dimensions of objects from measurements on photographs of the objects. Also called rarely and erroneously, metrical photography. A modifier is customarily used with the term to indicate the type of radiation causing the photographic image when this is not light, e.g., X-ray photogrammetry, infrared photogrammetry, and acoustic photogrammetry. The principal application of photogrammetry is to the mapping of the earth's surface, but it is also used for mapping the surface of other bodies in the solar system, for recording the geometry of architectural and archaeological objects, for making anthropometric measurements, and in many other sciences and technologies.

Picture Point
A terrain feature easily identified on an aerial photograph and whose horizontal or vertical position or both have been determined by survey measurements. Picture points

are marked on the aerial photographs by the surveyor, and are used by the photomapper.

Planetable
A field device for plotting the lines of a survey directly from observations. It consists essentially of a drawing board mounted on a tripod, with a leveling device designed as part of the board and tripod.

Planimetric Feature
Item detailed on a planimetric map, i.e. fire hydrant.

Plumb Line
The line of force in the geopotential field. The continuous curve to which the direction of gravity is everywhere tangential.

Positional Error
The amount by which the actual location of a cartographic feature fails to agree with the feature's true position.

Precision
The amount by which a measurement deviates from its mean.

Prime Meridian
The meridian of longitude 0°, used as the origin for measurement of longitude. The meridian of Greenwich, England, is almost universally used for this purpose.

Prime Vertical
The vertical circle through the east and west points of the horizon. It may be true, magnetic, compass, or grid depending upon which east or west points are involved.

Project Control
Used for a specific project.

Project Datum
Used for a specific project.

Projection
A set of functions, or the corresponding geometric constructions, relating points on one surface to points on another surface. A projection allows every point on the first surface to correspond exactly to one point on the second surface. A projection differs from a map projection in that the latter deals only with situations in which one surface is an ellipsoid and the other a developable surface.

Quadrangle
Consisting of four specified points and the lines or line segments on which they lie. The quadrangle and the quadrilateral may define the same shape. They differ in that the quadrangle is defined by four specified points, the quadrilateral by four specified lines or line-segments.

Quad Sheet
Slang for a USGS 1:24,000-scale map.

Random Error
Produced by irregular causes whose effects upon individual measurements are governed by no known law connecting them with circumstances and which therefore can never be subjected to computation a priori. Sometimes called an irregular error or, more commonly, an accidental error. The theory of elemental errors assumes that a random error is assumed to be composed of an infinite number of independent, infinitesimal errors, all of equal magnitude, each as likely to be positive as negative. In practice, a random error is composed of an indefinitely large number of finitely small errors, each as apt to be positive as negative. With these assumptions, probabilities can be associated with the results of the method of least squares, and it is to the elimination of random errors only that the method of least squares properly may be applied.

Range Pole
A simple rod, round or octagonal in section, 6 to 8 feet long, 1 inch or less in diameter, fitted with a sharp-pointed shoe of steel and usually painted alternately in red and white bands at 1-foot intervals. It may be made of wood or metal. It is used to line up a point of a survey or to show the observer at the theodolite the location of a point on the ground.

Readings
The number obtained by noting and/or recording that number which an instrument indicates is a result of the measurement.

Real-time
1. Represented as a real quantity rather than as an imaginary quantity. This is usually the case in relativistic mechanics; the other three, space-like coordinates are then imaginary quantities. However, many scientists treat the space-like coordinates as real and the time as imaginary. 2. Very close to the instant of observation or other activity. 3. Reported or recorded at the same time as they are

happening. 4. Absence of delay in getting, sending, and receiving data.

Reciprocal Leveling
Measuring vertical angles or making rod readings from two instrument positions for the purpose of compensating for earth curvature, the effects of atmospheric refraction, and some instrument misadjustments.

Rectangular Coordinate Systems
Coordinates on any system in which the axes of reference intersect at right angles.

Rectification (of datums)
Producing, from a tilted or oblique photograph, a photograph from which displacement due to tilt has been removed. Also called transformation. A photograph may be rectified optically, graphically, or mathematically. The optical method is the most common. The photograph is given the same orientation with respect to an unexposed photographic film or plate as the ground plane had to the photograph when the picture was taken. The image on the photograph is then projected onto the emulsion to reverse, in effect, the original process by which the photograph was taken. Graphical rectification involves plotting selected points from the photograph onto another sheet, using a graphical method of correcting for displacement because of tilt. Neither method compensates for radial displacement caused by relief. Mathematical rectification uses a computer as intermediary between the original photograph and the rectified image, correcting not only for nonverticality of the photograph but also, in suitable cases, for relief-caused displacement.

Redundant Measurements
Overabundant or excess measurements.

Reference Meridian, Magnetic
Based on the magnetic pole.

Reference Meridian, True
Based on the astronomical meridian.

Reference Point
Used as an origin from which measurements are taken or to which measurements are referred. Also called a datum point.

Refraction
The bending of sonic or electromagnetic rays by the substance through which the rays pass. The amount and direction of bending are determined by a characteristic of the substance called the refractive index. (Relativistic bending by a gravitational field is not refraction.)

Rejection Criterion
Set of rules and guidelines established for rejecting information, basically used in adjustments.

Relative Accuracy
1. The square root of the average of the sum of the squares of the differences between (a) a set of measured or calculated values and (b) a set of corresponding correct values, divided by the average value of the set; i.e., relative accuracy is equal to the accuracy divided by the average value of the set. This is a useful quantity because it is dimensionless and independent of the units in which the measurements were made. 2. A quantity expressing the effect of random errors on the location of one point or feature with respect to another. In particular, (a) an evaluation of the effect of the random errors in points on a map with respect to the graticule, excluding any errors in the graticule or the coordinate system of the graticule; or (b) an evaluation of the effect of random errors in determining the location of one point on a map with respect to another point on the same map.

Repeating Theodolite
Designed so that the sum of successive measurements of an angle can be read directly on the graduated horizontal circle. The vertical axis of rotation is represented physically by two concentric spindles. One of these lets the alidade be rotated independently of the horizontal circle and the other, by a clamp, lets the alidade and the horizontal circle rotate together. Also called a double-center theodolite, reiteration theodolite, engineer's transit, and repeating instrument. The value of the angle is obtained by dividing the total arc passed through (the final reading on the circle, plus an appropriate multiple of 360°) in making the series of measurements by the number of times the angle has been measured. In theory, the repeating theodolite is an instrument capable of giving very precise results; in practice, it does not give results as satisfactory as those obtained with a direction theodolite.

Resection
Determining the location of a point by extending lines of known direction from that point to two other known points. Equivalently, a procedure of determining the location by extending lines making known angles with a third line whose position and length are known. The procedure may be done on the ground using lines of sight as the lines extended, or may be done geometrically by plotting the points and drawing the lines to scale on a sheet, or

may be done algebraically by using the coordinates, angles, etc., of the points and lines involved.

Right Ascension
The angular distance measured eastward on the equator from the vernal equinox to the hour circle through the celestial body, from 0 to 24 hours.

Sea Level Datum of 1929
Adopted as a standard datum for heights. The sea level is subject to some variations from year to year, but, as the permanency of any datum is of prime importance in any engineering work, a sea-level datum after adoption should, in general, be maintained indefinitely even though differing slightly from later determinations of mean sea level based on longer series of observations.

Self-leveling Level
The line of sight is automatically maintained horizontal by means of a built-in pendulum device.

Semimajor Axis
The line from the center of an ellipse to the extremity of the longest diameter; i.e., one of the two longest lines from the center to the ellipse. The term is also used to mean the length of the line.

Semiminor Axis
The line from the center of an ellipse to the extremity of the shortest diameter; i.e., one of the two shortest lines from the center to the ellipse. The term is also used to mean the length of the line.

Sexagesimal System
Notation by increments of 60. As the division of the circle into 360°, each degree into 60 minutes, and each minute into 60 seconds.

Setup
1. In general, the situation in which a surveying instrument is in position at a point from which observations are made; e.g., measurements made at the last setup. 2. The actual physical process of placing a leveling instrument over an instrument station. 3. The surveying instrument itself when in position at a point from which observations are made. This last definition may be empty; in any event, its usage with this precise meaning seems to be rare. The terms instrument station and setup, especially in leveling, are often used interchangeably. However, if any distinction is made, setup is considered to be the instrument when mounted or set up over the instrument station or point on the ground which is on the axis of rotation of the instrument. 4. The horizontal distance from the fiducial mark on the front end of a tape, or on that end of the tape which is in use at the time, measured forward to the point, on the mark or monument, to which the particular distance is being measured. A setup is usually very small when measuring a baseline with stakes for supporting the tape put in place before measuring begins. If the distance between stakes is too great, the tape will not reach from stake to stake, and setups must be measured. If portable supports such as bucks are used, there will seldom be need for measuring setups. Setups are positive corrections to taped distances. 5. The positions given those parts of a stereoscopic plotting instrument which are adjustable but remain fixed while the instrument is in use.

Sidereal Day
The interval of time from a transit of the (true) vernal equinox across a given meridian to its next successive transit across the same meridian.

Sidereal Time
Time based upon the rotation of the earth relative to the vernal equinox.

Solar Day
1. The interval of time from the transit of either the sun or the mean sun across a given meridian to the next successive transit of the same body across the same meridian. 2. The duration of one rotation of the sun.

Spheroid
A mathematical figure closely approaching the geoid in form and size. Used as surface of reference for geodetic surveys.

Spirit Level
A closed glass tube (vial) of circular cross section. Its center line forms a circular arc, its interior surface is ground to precise form and filled with ether or liquid of low viscosity, enough free space being left for the formation of a bubble of air or gas.

Stadia Constant
The sum of the focal length of a telescope and the distance from the vertical axis of the instrument on which the telescope is mounted to the center of the objective lens system. Also called the anallactic constant and anallatic constant. It is not a constant for internally focusing telescopes.

Stadia Traverse
Distances are determined using a stadia rod. A stadia traverse is suited to regions of moderate relief with an adequate network of roads. If done carefully, such a

traverse can establish elevations accurate enough for compiling maps with any contour interval now standard.

Standard Error
The standard deviation of the errors associated with physical measurements of an unknown quantity, or statistical estimates of an unknown quantity or of a random variable.

Systematic Error
The algebraic sign and, to some extent, magnitude bear a fixed relation to some condition or set of conditions. In other words, an error which is, in theory at least, predictable and therefore is not a random error. Systematic errors are regular and therefore can be determined a priori. They are usually eliminated from a set of observations before applying the method of least squares to reduce or eliminate random errors. They are classified as theoretical (external) errors, instrumental errors, and personal errors, according to their origin and nature.

State Plane Coordinate System (SPCS)
A reference coordinate system used by the various states of the U.S.

Strength of Figure
A number relating the precision with which lengths of sides in a triangulation network can be determined, to the sizes of the angles, the number of conditions to be satisfied and the distribution of baselines and points of fixed location. Strength of figure, in triangulation, is not based on an absolute scale but rather is an expression of relative precision. The number is really a measure of a network's weakness, because the number increases in size as the strength decreases. By summing the values obtained for the simple figures composing a triangulation network, the strength of figure of the network is obtained. Because a triangulation network is usually composed of several different sets of simple figures, comparable numbers for the different sets can be obtained, and the route giving the strongest total network can then be selected for calculating lengths. Reconnaissance for a proposed triangulation network is usually done under instructions that specify limiting values of the strength of figure for the best and second-best chains of triangles between adjacent baselines; the sites for stations and for baselines are selected accordingly. Where desirable, the length of a section may be reduced by inserting an additional baseline, and the numbers for strength of figure reduced accordingly.

Strip Photography
Using a strip camera. The image of an object moving with respect to the camera is focused onto a surface containing a narrow slit. The film is moved along behind the slit, or the slit is moved over the surface of the film, at a rate compensating for the movement of the object. This method of image-motion compensation is much used in aerial photograph.

Structural Deformation Studies
Not only observations of the changes in the dam structure but the monitoring tries to answer the question of why these occurrences happen.

Subtense Bar
Carrying two easily visible marks a fixed, known distance apart and used for determining the distance from an observer to the bar by means of the angle subtended at the observer by the marks on the bar. The marks are often placed on fittings mounted at the ends of the bar and connected by invar wires under slight but constant tension. This counteracts the effect of temperature on the distance between marks. In use, the subtense bar is mounted horizontally on a tripod and centered over the mark to which distance is to be determined. The angle subtended at the observing instrument is measured and automatically converted by the instrument to distance. The observer reads off the distance, not the subtended angle.

Tangent Plane Grid System
The origin at the point of tangency. Usually the origin is designated 10,000 N and 10,000 E, or some similar amounts, to keep all coordinates positive. This system never extends for any great distance.

Taping
Measuring a distance on the earth, using a surveyor's tape. The persons who mark the two ends in taping are called contact men or, particularly when measuring baselines, tape men or tapemen. The term taping is used in this sense in all surveys except in those of the public lands of the U.S.; in those surveys, for historical and legal reasons, the terms chaining and chainmen are preferred.

Three-wire Leveling
Three horizontal lines are used. The scale on the leveling rod is read at each of the three lines and the average is used for the final result.

Topographic Map
Showing the horizontal and vertical locations of the natural and man-made features represented. Also called a relief map. A topographic map is distinguished from a planimetric map by the presence, in the former, of symbols showing relief in measurable form. A topographic

map usually shows the same features as a planimetric map but uses numbered contour lines or comparable symbols to show mountains, valleys, and plains. In the case of hydrographic charts, it uses symbols and numbers to show depths in bodies of water. A topographic map differs from a hypsographic map in that, on the latter, vertical distances are shown with respect to the geoid, while on the former, vertical distances may be referred to any suitable and specified surface.

Transformation
Converting a position from Universal Transverse Mercator (UTM) or other grid coordinates to geodetic, and vice versa; from one datum and ellipsoid to another using datum shift constants and ellipsoid parameters.

Transit
The apparent passage of a star or other celestial body across a defined line of the celestial sphere, as a meridian, prime vertical, or almucantar. The apparent passage of a star or other celestial body across a line in the reticule of a telescope, or some line of sight. The apparent passage of a smaller celestial body across the disk of a larger celestial body. The transit of a star across the meridian occurs at the moment of its culmination, and the two terms are sometimes used as having identical meanings; such usage is not correct, even where the instrument is in perfect adjustment. At the poles, a star may have no culmination but it will transit the meridians.

Transit Rule
The correction to be applied to the departure (or latitude) of any course has the same ratio to the total misclosure in departure (or latitude) as the departure (latitude) of the course has to the arithmetical sum of all the departures (latitudes) in the traverse. The transit rule is often used when it is believed that the misclosure is caused less by errors in the measured angles than by errors in the measured distances. It meets the assumptions on which it is based only when the courses are parallel to the axes of the coordinate system used. Care must be taken in applying the rule because there is not universal agreement on what sign should be used for the misclosure.

Transverse Mercator Projection
The central meridian, or a pair of lines virtually parallel to the central meridian, is mapped into a straight line and exactly to scale. It is essentially the same as a Mercator map-projection preceded by a rotation of the ellipsoid through 90° about a major axis. Equivalently, it is the same as a Mercator map-projection calculated for a cylinder with axis in the equatorial plane.

Traverse
1. A route and the sequence of points on it at which observations or measurements are made.
2. A route, the sequence of points on it at which measurements are made, and the measurements themselves.
3. The process by which a route and a sequence of points of measurement on it are established.

Triangulation
The points whose locations are to be determined, together with a suitable number (at least two) of points of known location, are connected in such a way as to form the vertices of a network of triangles. The angles in the network are measured and the lengths of the sides (i.e., the distances between points) are either measured (at least one distance must be measured or calculated from known points) or are calculated from measured angles and measured or calculated distances. The sides having measured lengths are called baselines. Classically, only a very few short baselines are in the network; these are connected by the sides of triangles of normal size by a sequence of triangles of increasing size. Triangulation permits sites for stations and baselines favorable for use both from topographic and geometric considerations to be selected. It is well adapted to the use of precise instruments and methods and can yield results of great accuracy and precision. It has been used generally where the region to be surveyed was large. The term can be considered as including not only the actual operations of measuring angles and baselines, and the reduction of the data, but also the reconnaissance which precedes those operations and any astronomic observations which are required.

Tribrach
The three-armed base of a surveying instrument in which the foot screws used in leveling the instrument are placed at the ends of the arms. Also called a leveling base or leveling head. Some surveying instruments have a four-armed base or quadribrach in which are the foot screws. Tribrachs are used instead of quadribrachs for control surveys because they do not introduce strains into the base of the instrument; quadribrachs do. Some strains tend to change the instrument's orientation in azimuth during the measuring.

Trigonometric Leveling
The determination of differences of elevation trigonometrically from observed vertical angles and measured or computed horizontal or inclined distances.

Trilateration (positioning)
Method of position determination using the intersection of two or more distances to a point.

Universal Transverse Mercator
A worldwide metric military coordinate system rarely used for civil works applications.

U.S. Coast & Geodetic Survey (USC&GS)
Now known as National Ocean Service (NOS).

U.S. Survey Foot
The unit of length defined by the relationship 1 foot ≡ (1/3)(3,600/3,937) m. Established by the U.S. Coast and Geodetic Survey as published in its Bulletin No. 26 (5 April 1893).

Variance-Covariance Matrix
A matrix whose element in row i and column j is the average value of $(x_i - \mu_i)(x_j - \mu_j)$, where x_i and x_j are random variables with average values μ_i and μ_j, respectively. The elements along the main diagonal are called the variances of the corresponding variables; the elements off the main diagonal are called the covariances.

Variance of Unit Weight
Arbitrary scale factor multiplied by the variance-covariance matrix to obtain the weight matrix.

Vernal Equinox
That point of intersection of the ecliptic and the celestial equator, occupied by the sun as it changes from south to north declination, on or about March 21. Same as first as Aries; first point of Aries; March equinox.

Vernier
An auxiliary scale sliding against and used in reading a primary scale. The total length of a given number of divisions on a vernier is equal to the total length of one more or one less than the same number of divisions on the primary scaled. The vernier makes it possible to read a principal scale (such as a divided circle) much closer than one division of that scale. If a division on the primary scale is longer than a single division on the vernier, it is a direct vernier; if a division on the vernier is the longer, it is a retrograde vernier, so called because its numbers run in the opposite direction from those on the primary scale. The direct vernier is the usual type and is used in reading the circles on an engineer's transit and on a repeating theodolite. Two verniers extending and numbered in opposite directions from the same index form a *double vernier*, used in reading a circle having graduations numbered in both directions. A *single vernier* so constructed and numbered that it may be read in either direction is termed a *folding vernier*.

VERTCON
Acronym for vertical datum conversion. VERTCON is the computer software that converts orthometric heights from NGVD 29 to NAVD 88 and vice versa.

Vertical Adjustment Residual
Difference in measured and predicted vertical observations.

Vertical Angle
An angle in a vertical plane. One of the sides of a vertical angle is usually either (a) a horizontal line in the vertical plane or (b) a vertical line in that plane. In case (a), the angle is then called, also, the angular elevation or angular depression or altitude. In case (b), it is also called the zenith angle. The vertical angle between two lines, neither of which is horizontal or vertical, is usually obtained by a combination of two vertical angles as defined previously.

Vertical Circle
1. A great circle of the celestial sphere, through the zenith and nadir. Vertical circles are perpendicular to the horizon. 2. A graduated disk mounted on an instrument in such a manner that the plane of its graduated surface can be placed in a vertical plane. It is primarily used for measuring vertical angles in astronomical and geodetic work.

Vertical Datum
Any level surface (as for example mean sea level) taken as a surface of reference from which to reckon elevations. Although a level surface is not a plane, the vertical datum is frequently referred to as the datum plane. Also called datum level, reference level, reference plane, vertical control datum, vertical geodetic datum.

Vertical Refraction
That component of refraction occurring in a vertical plane. Two kinds of vertical refraction affect surveying: that caused by the curvature of the atmospheric layers of different densities (important principally in aerial photogrammetry), and that caused by temperature gradients near the ground (important principally in spirit leveling and trigonometrical leveling).

Weight
The force with which a planet or satellite attracts a body on its surface. In particular, the force with which the earth attracts a body on its surface. The weight is equal

to the product of the mass of the body by the acceleration imparted by gravity. It should not be confused with the mass of the body (as the U.S. Bureau of Standards does). Note that the body must be on the surface of the planet or satellite or attached to it in some manner. Otherwise the body does not participate in the rotation of the attracting body.

Weighted Mean
1. The sum of the products of each number in a set {X} multiplied by a corresponding number in a set (w), this sum being divided by the sum of the numbers in set (w); i.e., the weighted mean X(W) is given by $(\Sigma wX)/(\Sigma w)$. The quantities w are often defined so that they lie between 0 and +1 and $\Sigma w = 1$. Also called the weighed arithmetic mean. 2. If X is a continuous function with the known probability density p(X), then the weighted mean of X is the integral of [p(X)X]dX.

World Geodetic System of 1984 (WGS 84)
A set of constants specified by the U.S. Department of Defense in 1984 and consisting of the following constants: a datum, the coordinate system of which has its origin at the earth's center of mass; the coordinates, in that datum, of a number of points around the world; constants for transforming from other datums to the System's datum; and values determining the earth's gravity-potential.

Wye Level
Having the telescope and attached spirit level supported in wyes (Y's) in which it can be rotated about its longitudinal axis (collimation axis) and from which it can be lifted and reversed, end for end. Also called a Y-level and wye-type leveling instrument. The wye level was invented in 1740 by J. Sissons. The adjustments made possible by this mounting are peculiar to the instrument. The wye level is one of two general classes of leveling instruments, the other being represented by the dumpy level.

Zenith
The point where an infinite extension of a plumb (vertical) line, at the observer's position, pierces the celestial sphere above the observer's head.

Zenith Angle
Measured in a positive direction downward from the observer's zenith to the object observed. Also called zenith distance and colatitude. It is usually denoted by ζ or by z. The former is preferred except when it may be confused with the deflection of the vertical (also usually denoted by ζ).

Zenith Distance
The complement of the altitude, the angular distance from the zenith of the celestial body measured along a vertical circle.